

White Roofs to Cool your Building, your City and
(this is new !) Cool the World

Int'l. Conf. on Accelerated Aging of Cool Roofs
Berkeley, CA July 28, 2011

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Presentation available at www.ArtRosenfeld.org

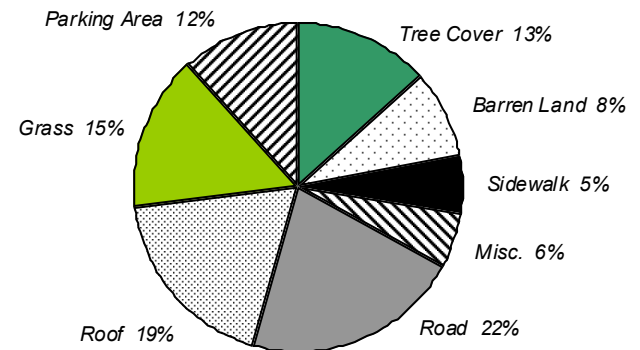
Filename Accel Aging, from EESI DC fm Blum Center from Russian Talk 6-5-11 + DR from EE
Summit Sactp. . Path DinnerTalk Life at CEC. ARPA-E

Bird's eye view of urban land use



The surface of Sacramento, CA is about

- **20% roofs**
- **30% vegetation**
- **40% pavement**



Area by Land-Cover Category Above the Canopy

~ 1 km²

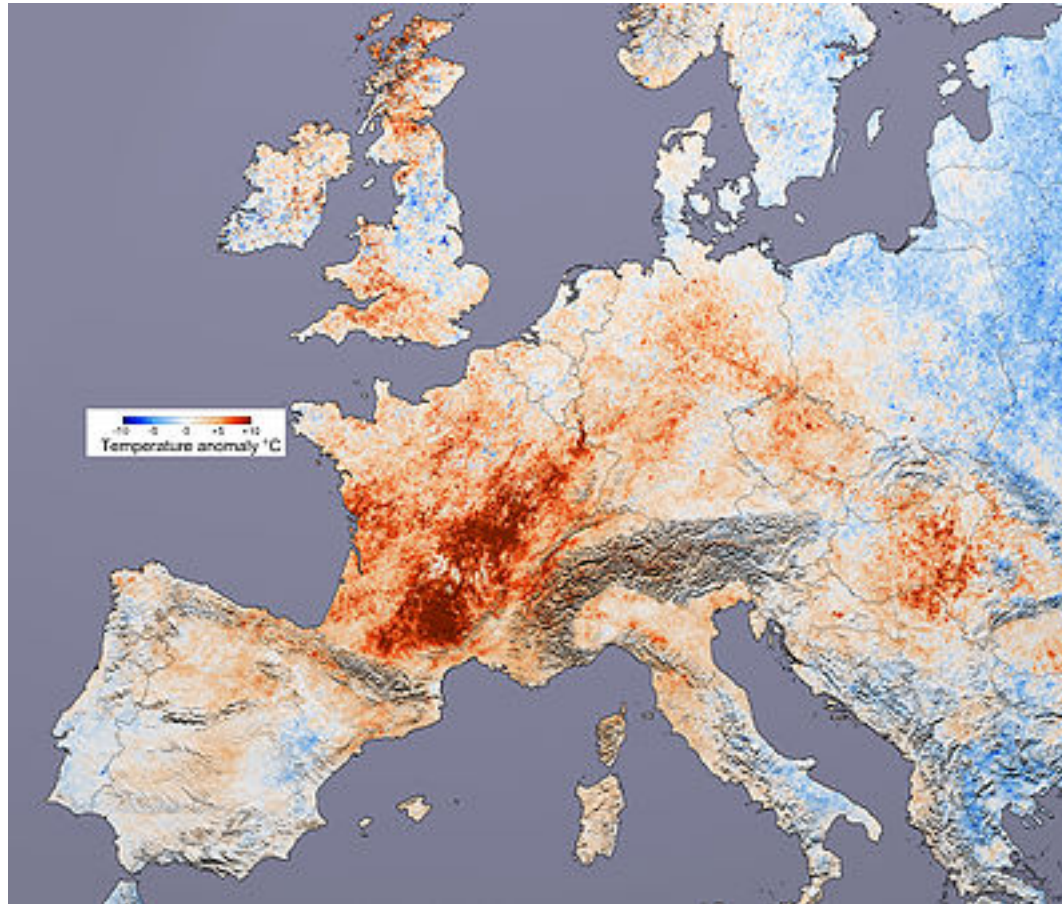
Chicago Heat Wave 1995, 739 Deaths

The highest risk group lived on
the top floors of buildings with black roofs



European Heat Wave 2003, 30,000 Deaths

Moscow-Centered Heat Wave 2010, ~10,000 Deaths



White roofs around the world

...in Santorini, Greece



...in Hyderabad, India

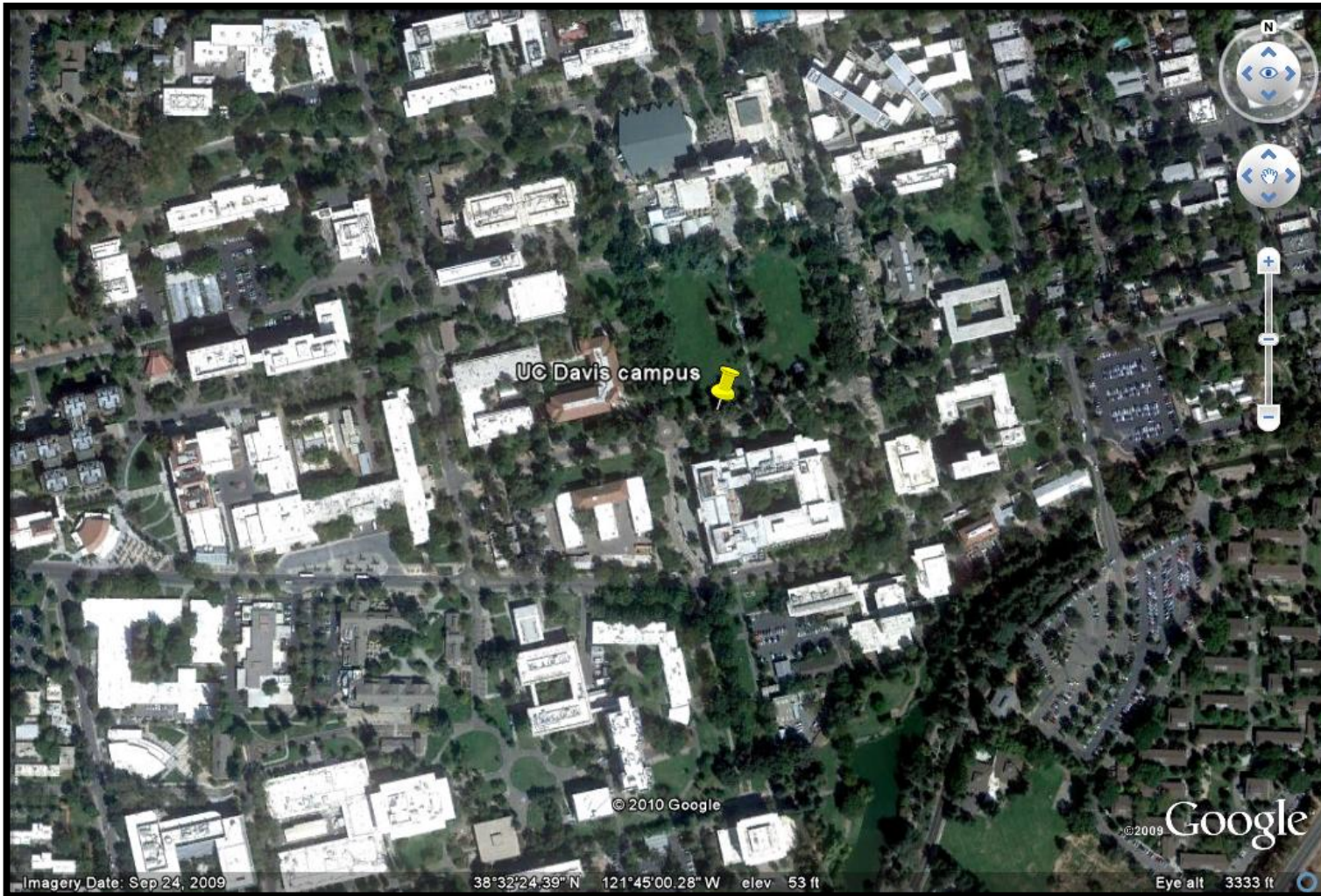


**...and widely
in the state of
Gujarat, India.**

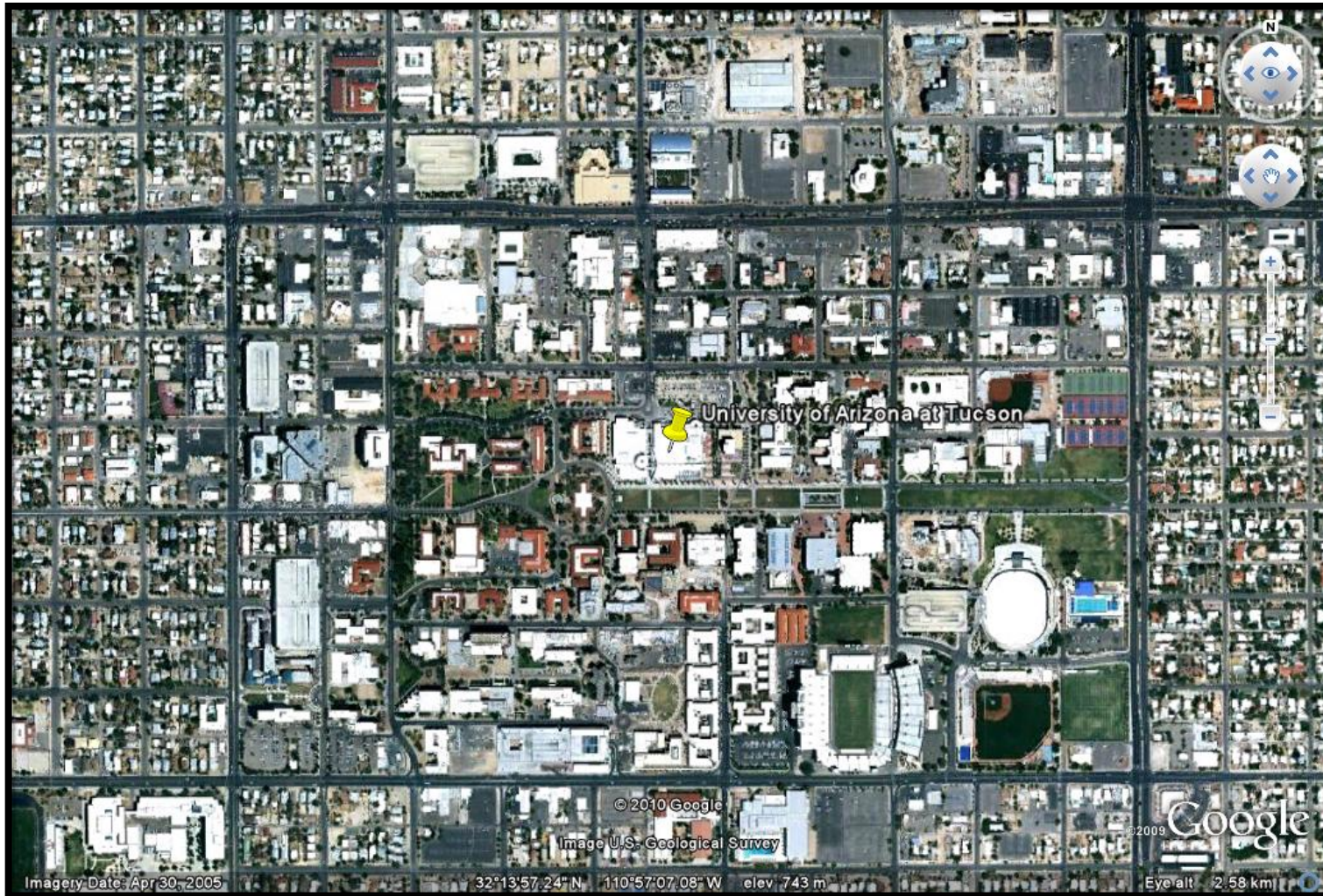
Walmart store in northern California, ~2005



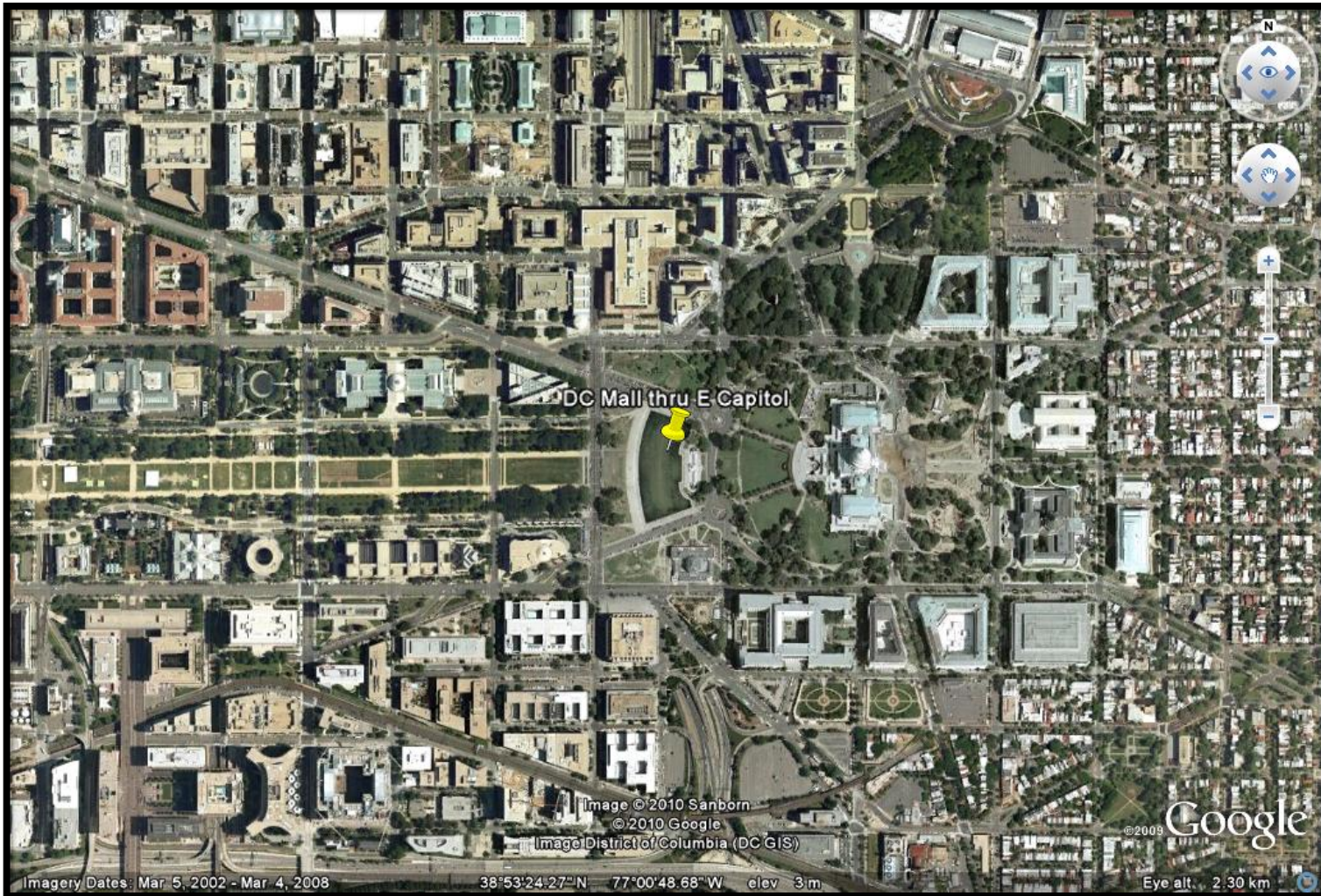
Congratulations to UC Davis



White roofs are popular in Tucson, AZ



Washington, DC (Federal) has problems



Pentagon



Cooling our planet

Reference Book

Consider a Spherical Cow

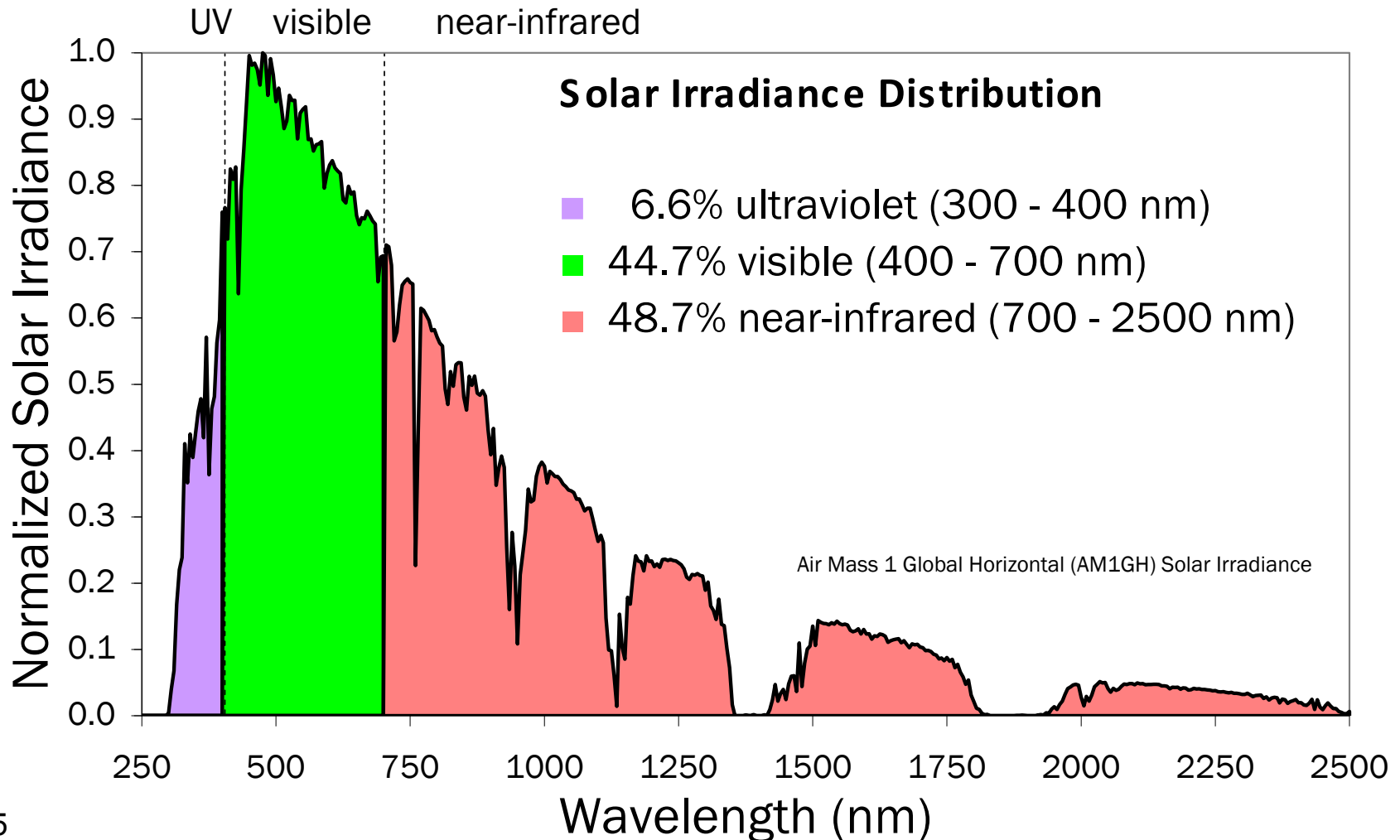
(A Course in Environmental Problem Solving)

By John Harte, UC Berkeley

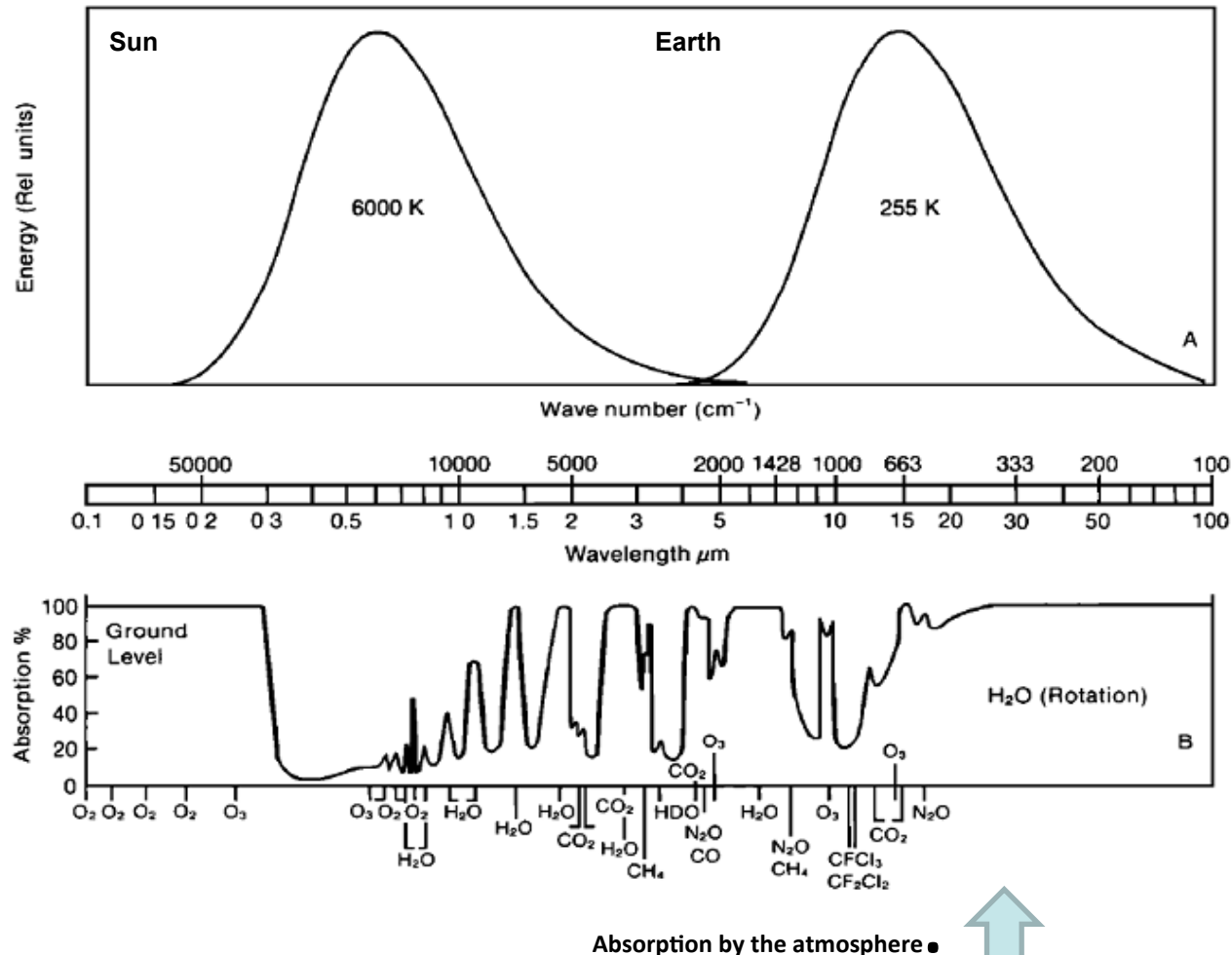
University Science Books, Mill Valley, CA 1988

Urban Heat Islands Ch3.B.9

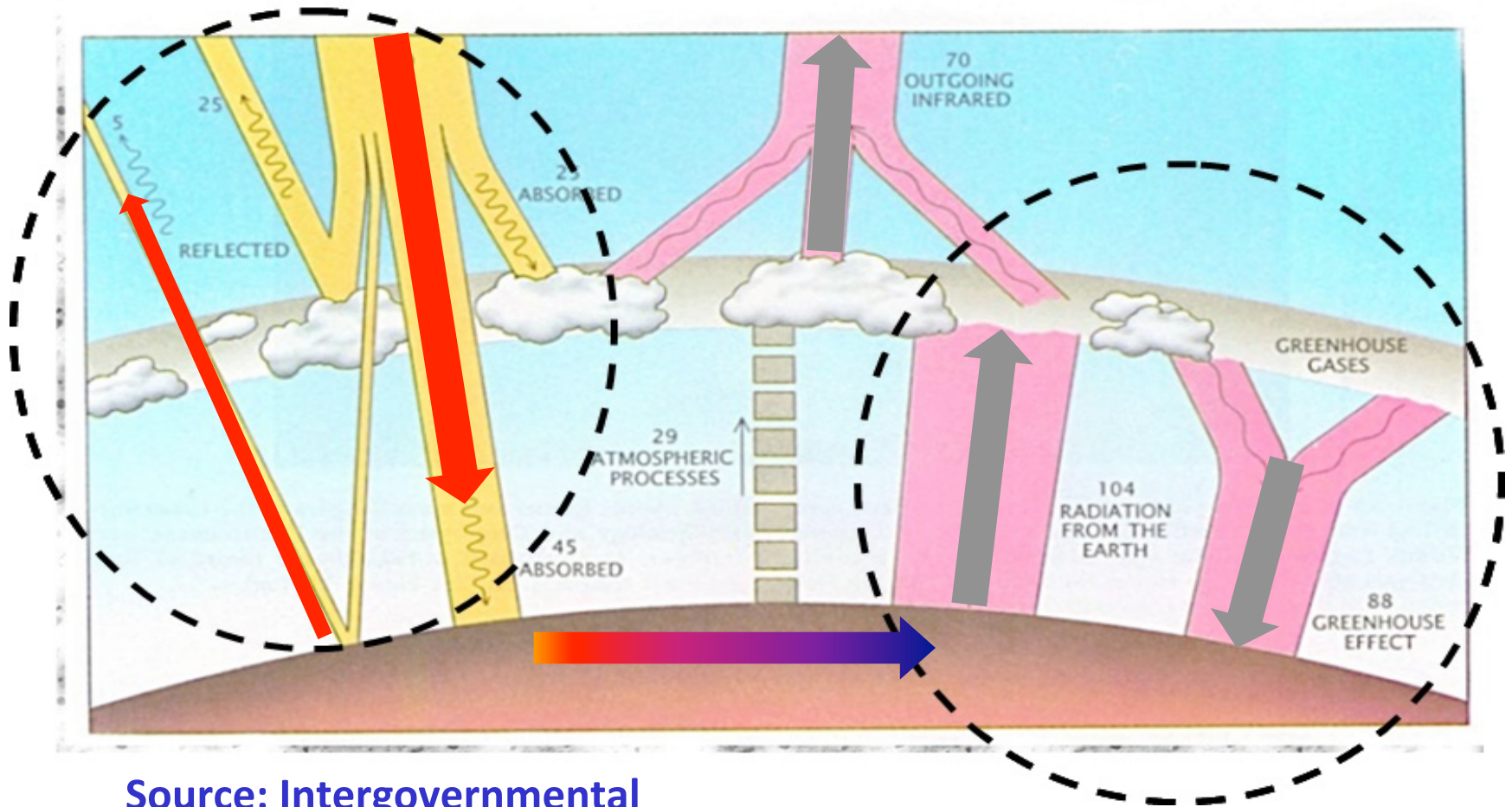
Sunlight — more than meets the eye



Atmospheric greenhouse effect (i/ii)



Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental
Panel on Climate Change (IPCC)

GLOBAL COOLING: making 100 m² (1000 ft²) of gray roofing white offsets the **emission** of 10 t of CO₂



How much CO₂ equivalent is offset if we whiten all eligible urban flat roofs worldwide? (i/ii)

- Answer: **24 Gigatonnes (Gt)**
 - 2/3 of a year's worldwide emission
 - Gigatonne = billion metric tons
- If implemented over 20 years (the life of a roof or a program) this is ≈ 1.2 Gt/year.

How much CO₂ equivalent is offset if we whiten all eligible urban flat roofs world-wide? (ii/ii)

- Offset is equivalent to **taking 300 million cars off the road for 20 years.**
 - There are about 600 million passenger cars world wide, and they each emit $\approx 4 \text{ t CO}_2/\text{year}$.



In terms of avoided power plants

Full white roof potential can *offset* the **emissions from 500 medium-sized coal fired power plants or 1,000 medium-sized gas fired power plants.**

That is just the albedo effect – if the building is air conditioned, it will also avoid comparable *real* CO₂ back at the power plant.

3 papers and 1 memo estimate tonnes of CO₂ offset by 100 m² (1000 ft²) of white roof. May 2010

	Study (available at CoolWhitePlanet.org)	Method	Cloud cover esti- mation	CO ₂ offset (atmos- pheric) per 100 m ²	CO ₂ offset (emitted) per 100 m ²	World-wide potential CO ₂ offset (emitted) from cool roofs	CO ₂ offset compared to Akbari et al. 2009
1	Akbari et al. 2009 (LBNL)	calculation	~ 50%	5.5 t	10 t	24 Gt	100%
2	Menon et al. 2010 (LBNL)	GCM + land use model (summer only)	GCM	7 t	13 t	30 Gt	130%
3	Oleson et al. 2010 (NCAR) [CO ₂ values from private communication between Oleson & Menon]	GCM + urban canyon model	GCM	7 t	13 t	30 Gt	130%
4	VanCuren et al. 2010 (CARB)	measured solar radiation	not needed	3 t	5 t	Addresses CA only; coastal CA is foggy.	50%

It is assumed that of 1 tonne of CO₂ *emitted* only 0.55 tonnes remain in the *atmosphere* after one year,
2: so the *atmospheric* and *emitted* columns are just in the ratio of 0.55/1.

Corroborations Since 2010

Vancuren, et al. is now refereed and published.

Franco Cotana, et al., University of Perugia, will present their 2008 paper at Lawrence Berkeley National Laboratory (LBNL) on July 28th, 2011. They estimate 7 tonnes of CO₂ offset per 100 m² vs. 10 by Akbari, et al.

Hear Anna Pisello & Frederico Rossi at lunch Friday.

All estimates so far agree within a factor of 2.

Now we need calculations for **individual regions**.



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SCIENCE AT THE THEATER

COOL CITIES, COOL PLANET

What to do now

Progress in energy efficiency standards

- In 2005, California's "Title 24" energy efficiency standards prescribed white surfaces for low-sloped roofs on commercial buildings. Several hot states are following. **Also New York City, effective January 2012. Vegetated ("green") roofs are deemed "white."**
- In 2008, California prescribed "cool colored" surfaces for steep residential roofs in its 5 hottest out of 16 climate zones.
- **Other U.S. states & all countries with hot summers should follow.**

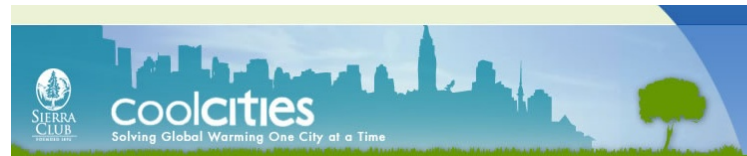
Recent cool roof progress (2005 – 2011)

- 2005
 - California Title 24 – “Flat roofs shall be white” (15 out of 16 climate zones). Walmart adopts white roofs for ALL stores.
 - EPA ENERGY STAR lists Cool Roof Materials
- 2010
 - June 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
 - June 16th, 2010 – Marine Corp follows suit, Pentagon following slowly
 - June 19th, 2010 – *RetroFIT Philly* announces winner of “coolest block” contest to white-coat black roofs of row houses.
- 2011
 - 100 Cool Cities launched – see www.GlobalCoolCitiesAlliance.org
 - Spring 2011 – US launched, at annual G20 Energy Ministers meeting, a voluntary Cool Roofs Working Group, and offered technical assistance to developing countries who join early. India, Mexico, have joined so far, with Japan expected.

To come 2012, 2013

- Model codes will be modified to prescribe “flat roofs shall be white”
 - ASHRAE 90.1(2013) for commercial buildings
 - EECC(2-12) for residential and commercial buildings
- But states and cities still must **adopt** model codes

Global Cool Cities Alliance could unite many initiatives and trade associations



EMERALD CITIES COLLABORATIVE
GREEN • FAIR • DEMOCRATIC



American Council for an Energy-Efficient Economy

THE CLIMATE GROUP

What about “Green” (Vegetated) Roofs?

ADVANTAGES

- In a rainy summer they cool buildings and cities comparably with white roofs.
- They hold up ~half of storm water.

DISADVANTAGES

- Their albedo is only ~20%, so they absorb sunshine, get warm, and then cool by evapo-transpiration. The absorbed heat is trapped by the greenhouse effect and the cooling by evaporation is cancelled within hours or days by the condensation of the water vapor into rain.
- For global cooling they are only one-third as effective as white roofs.
- Their first cost is ~\$15/sq. ft. (depending on roof type) and may need an irrigation system.
- I support them, but, as a 5% niche, they can be a distraction.

Resources on the web

- **Art Rosenfeld's website**
 - ArtRosenfeld.org
- **Cool Colors Project**
 - CoolColors.LBL.gov
- **Heat Island Group**
 - HeatIsland.LBL.gov
- **Cool Communities Project**
 - CoolCommunities.LBL.gov
- **Roof Savings Calculator**
 - RoofCalc.com
- **Global Cool Cities Alliance**
 - GlobalCoolCities.org
- **Cool Roof Rating Council**
 - CoolRoofs.org
- **Cool California**
 - CoolCalifornia.org
- **EPA Heat Islands**
 - epa.gov/heatisland
- **Energy Star Cool Roofs**
 - EnergyStar.gov